JC05 Rec'd PCT/PTO 1 1 MAY 2001

FORM PTO-1390 (REV 12-29-99) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	
6056-000040	
U.S. APPLICATION NO. (If known, see 37 CFR 1.5)	
09/831698	

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE99/03570	November 9, 1999	November 13, 1998

TITLE OF INVENTION CO_2 Slab Laser

APPLICANT(S) FOR DO/EO/US Norbert Taufenbach

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [x] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [x] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [x] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [x] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [x] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [x] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [x] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [x] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [x] Other items or information:

    Express Mail Transmittal
    Six sheets of formal drawings

US APPLICATION NO (if known, see 37 CFR 1.5) 09/831698	INTERNATIONAL APPLICATION NO PCT/DE99/03570	ATTORNEY'S DOCKET NUMBER 6056-000040

17. ☐ The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $970.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $840.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $690.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) $670.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $96.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	- 20 =		X $18.00	$	
Independent claims	- 3 =		X $78.00	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $260.00	$	
TOTAL OF ABOVE CALCULATIONS =				$	
Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$	
Processing fee of **$130.00** for furnishing the English translation later than ☐20 ☐30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED =				$	
				Amount to be: refunded	$
				charged	$

a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☐ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. _____. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Richard L. Carlson
Harness, Dickey & Pierce, P.L.C.
P. O. Box 828
Bloomfield Hills, MI 48303

SIGNATURE

Richard L. Carlson
NAME

27863
REGISTRATION NUMBER

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:

Filing Date:

Applicant: Norbert Taufenbach

Group Art Unit:

Examiner:

Title: CO_2 Slab Laser

Attorney Docket: 6056-000040

Hon. Commissioner of Patents and Trademarks
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Preliminary to the examination of this application on its merits, please enter the following amendments:

IN THE CLAIMS:

Please cancel Claims 4, 6, 7, 8, 10, 12 and 13 without prejudice.

Please amend the claims in accordance with the following rewritten claims in clean form. Applicant includes herewith an Attachment for Claim Amendments showing a marked up version of each amended claim in which underlines indicate insertions and brackets indicate deletions.

9. (Amended) CO_2-Slablaser nach Anspruch 1, dadurch gekennzeichnet, daß das Federlager ein Balg ist.

REMARKS

The above amendments are being presented to eliminate the multiple dependent claims as presented in this German language application. It is anticipated that some or all of these claims will be represented at the time an English language translation of this application is filed.

Respectfully submitted,

By: _____
Richard L. Carlson
Reg. No. 27863
Attorney for Applicant

Harness, Dickey & Pierce, P.L.C.
P. O. Box 828
Bloomfield Hills, MI 48303
(248) 641-1600

May 11, 2001
RLC/jb

ATTACHMENT FOR CLAIM AMENDMENTS

The following is a marked up version of the amended claim in which underlines indicates insertions and brackets indicate deletions.

9. (Amended) CO_2-Slablaser nach Anspruch [7] 1, dadurch gekennzeichnet, daß das Federlager ein Balg ist.

Attorney Docket 6056-000040

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Norbert Taufenbach

Serial No. 09/831,698

Filed: May 11, 2001

For: $C0_2$ SLAB LASER

Hon. Commissioner of Patents & Trademarks
Washington, D.C. 20231

SECOND PRELIMINARY AMENDMENT

Sir:

Prior to the examination of this application, please amend it as follows:

IN THE SPECIFICATION

Please replace the following paragraphs of the specification. Applicant includes herewith an Attachment for Specification Amendments showing a marked up version of each replacement paragraph.

Page 1, before the first paragraph, please insert the following header:

BACKGROUND AND SUMMARY OF THE INVENTION

Page 6, between lines 4 and 5, please add the as following header:

BRIEF DESCRIPTION OF THE DRAWINGS

Please replace the paragraph beginning on page 6, line 7 with the following paragraph in clean form:

Fig. 1 is a perspective view showing a laser according to the invention with cooling means at both ends;

Please replace the paragraph beginning on page 6, line 9 with the following paragraph in clean form:

Fig. 2 is a perspective view of the laser according to the invention with the cooling fins removed and portions thereof broken away, where the two electrodes with cooling medium channels, as well as the structure of the end pieces with flexible bearings, can be seen;

Please replace the paragraph beginning on page 6, line 12 with the following paragraph in clean form:

Fig. 3 is a perspective view of a flexible bearing end piece utilized in the laser of Figure 1;

Please replace the paragraph beginning on page 6, line 13 with the following paragraph in clean form:

Fig. 4 is a section view of the flexible bearing end piece of Fig. 3;

Please replace the paragraph beginning on page 6, line 14 with the following paragraph in clean form:

Fig. 5 is a longitudinal section view of the laser structure of Fig. 2 with the section being taken along a plane passing through the longitudinal axis thereof;

Please replace the paragraph beginning on page 6, line 15 with the following paragraph in clean form:

Fig. 6 is an exploded view of the laser structure of Figure 1 with a shielding netting surrounding the tubular housing all in accordance with the present invention; and

Please replace the paragraph beginning on page 6, line 17 with the following paragraph in clean form:

Fig. 7 is a perspective view of a laser structure with a tubular housing that in its center is provided with a flexible bellows all in accordance with the present invention.

On page 6, between lines 18 and 19, please insert the following header:

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Please replace the paragraph beginning on page 7, line 12 with the following paragraph in clean form:

This makes it possible, by means of the adjusting screws 20, to adjust the end pieces, which as shown in Fig. 2, each support one of the two electrodes fastened on the outer (movable) section 24, by means of the adjusting screws 20 in the angular position to the other electrode in each instance (in Fig. 2) to the electrode 36, which is fastened at the left end.

IN THE CLAIMS

Please amend the claims in accordance with the following rewritten claims in

clean form. Applicant includes herewith an Attachment for Claim Amendments showing a marked up version of each amended claim.

1. (Amended) A CO_2 slab laser having a gas-filled chamber defined by a tubular housing (10), with at least two electrodes that extend into the tubular housing, said electrodes overlapping one another and forming a discharge chamber, and resonator mirrors provided within said housing, characterized in that

said electrodes are each supported at the opposite ends of said tubular housing,

said mirrors are supported in stationary relationship relative to the electrodes and

said electrodes and mirrors are adjustable relative to one another.

2. (AMENDED) A CO_2 slab laser having a gas-filled chamber defined by a tubular housing, with at least two electrodes that extend into the tubular housing, said electrodes overlapping one another and forming a discharge chamber, and resonator mirrors provided within said housing, characterized in that

said electrodes are each supported at the opposite ends of said tubular housing,

said mirrors are designed in one piece with said electrodes and

said electrodes and mirrors are adjustable relative to one another.

3. (Amended) A CO_2 slab laser having a gas-filled chamber defined by a tubular housing (10), with at least two electrodes that extend into the

tubular housing, said electrodes overlapping one another and forming a discharge chamber, and resonator mirrors provided within said housing, characterized in that

said electrodes each are held at the opposite ends of said tubular housing,

said mirrors are supported in stationary relationship relative to said electrodes and

said electrodes and said mirrors are adjustable relative to one another.

5. (Amended) A CO_2 slab laser according to Claim 3, characterized in that the electrodes are designed in one piece with the end pieces.

9. (Amended) A CO_2 slab laser according to Claim 7, characterized in that the flexible bearing is a bellows.

11. (Amended) A CO_2 slab laser according to Claim 9, characterized in that the adjusting elements contain piezoelectric crystals which are capable of being driven electrically.

Please add the following new claims:

14. (Added) A CO_2 slab laser having a gas-filled chamber defined by a tubular housing as set forth in Claim 2, characterized in that the electrodes are held by the end pieces sealing off the tubular housing.

15. (Added) A CO_2 slab laser according to Claim 3, characterized in that said mirrors are designed in one piece with end pieces forming a part of said housing.

16. (Added) A CO_2 slab laser according to Claim 4, characterized in that said mirrors are designed in one piece with end pieces forming a part of said housing.

17. (Added) A CO_2 slab laser according to Claim 1, characterized in that the tubular housing (10) is designed in two parts, said two parts being interconnected and adjustable relative to one another.

18. (Added) A CO_2 slab laser according to Claim 2, characterized in that the tubular housing (10) is designed in two parts, said two parts being interconnected and adjustable relative to one another.

19. (Added) A CO_2 slab laser according to Claim 3, characterized in that the tubular housing (10) is designed in two parts, said two parts being interconnected and adjustable relative to one another.

20. (Added) A CO_2 slab laser according to Claim 5 characterized in that the tubular housing (10) is designed in two parts, said two parts being interconnected and adjustable relative to one another.

21. (Added) A CO_2 slab laser according to Claim 14, characterized in that the tubular housing (10) is designed in two parts, said two parts being interconnected and adjustable relative to one another.

22. (Added) A CO_2 slab laser according to Claim 15, characterized in that the tubular housing (10) is designed in two parts, said two parts being interconnected and adjustable relative to one another.

23. (Added) A CO_2 slab laser according to Claim 16, characterized in that the tubular housing (10) is designed in two parts, said two parts being interconnected and adjustable relative to one another.

24. (Added) A CO_2 slab laser according to Claim 3, characterized in that at least one of the end pieces defining said housing is attached to the tubular housing (10) by way of a flexible bearing.

25. (Added) A CO_2 slab laser according to Claim 4, characterized in that at least one of the end pieces defining said housing is attached to the tubular housing (10) by way of a flexible bearing.

26. (Added) A CO_2 slab laser according to Claim 5, characterized in that at least one of the end pieces defining said housing is attached to the tubular housing (10) by way of a flexible bearing.

27. (Added) A CO_2 slab laser according to Claim 1, characterized by adjusting elements (20) that are supported on the tubular housing and act on the electrodes.

28. (Added) A CO_2 slab laser according to Claim 1, characterized in that the tubular housing (10) is designed cylindrical and the electrodes in section form a circular segment whose radius is smaller than the inside radius of the tubular housing.

29. (Added) A CO_2 slab laser according to Claim 1, characterized in that the electrodes and hence the mirrors are fixed relative to one another after adjustment.

REMARKS

The Examiner is advised that the above amendments are being made with respect to the English language translation of the subject application and hence all references are with respect to the certified translation previously filed.

Claims 1-3, 5, 9, and 11 have each been amended to place them in better form for examination and claims 14 through 29 have been added by way of this amendment. Claims 14-29 correspond in modified form to previously cancelled claims 4, 6, 7, 8, 10, 12 and 13.

Favorable consideration and allowance of this application is respectfully requested.

Respectfully submitted,

By: 

Richard L. Carlson
Reg. No. 27,863
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Bloomfield Hills, MI 48303
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January 14, 2002
RLC/jb

ATTACHMENT FOR SPECIFICATION AMENDMENTS

The following is a marked up version of each replacement paragraph and/or section of the specification in which underlines indicates insertions and brackets indicate deletions.

Page 1, before the first paragraph, please insert the following header:

BACKGROUND AND SUMMARY OF THE INVENTION

Page 6, between lines 4 and 5, please insert the following header::

BRIEF DESCRIPTION OF THE DRAWINGS

Please amend the paragraph beginning on page 6, line 7 as follows:

Fig. 1 [shows the] is a perspective view showing a laser according to the invention with cooling means at both ends [in a perspective general view];

Please amend the paragraph beginning on page 6, line 9 as follows:

Fig. 2[,] is a perspective view of the laser according to the invention [for external cooling circuit in a partial sectional view] with the cooling fins removed and portions thereof broken away, where the two electrodes with cooling medium channels, as well as the structure of the end pieces with flexible bearings, can be seen;

Please amend the paragraph beginning on page 6, line 12 as follows:

Fig. 3[,] is a perspective view of a flexible bearing end piece [in a perspective view] utilized in the laser of Figure 1;

Please amend the paragraph beginning on page 6, line 13 as follows:

Fig. 4[,] is a section view of the flexible bearing [the] end piece of Fig. 3 [in a sectional view];

Please amend the paragraph beginning on page 6, line 14 as follows:

Fig. 5[,] is a longitudinal sectional view of the laser structure of Fig. 2 [in longitudinal section] with the section being taken along a plane passing through the longitudinal axis thereof;

Please amend the paragraph beginning on page 6, line 15 as follows:

Fig. 6[,] is an exploded view of the laser structure of Figure 1 with a shielding netting surrounding the tubular housing all in accordance with the present invention; and

Please amend the paragraph beginning on page 6, line 17 as follows:

Fig. 7[,] is a perspective view of a laser structure with a tubular housing that in its center is provided with a flexible bellows all in accordance with the present invention.

On page 6, between lines 18 and 19, please insert the following header:

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Please amend the paragraph beginning on page 7, line 13 as follows:

This makes it possible, by means of the adjusting screws 20, to adjust the end pieces, which as shown in Fig. 2, each [bear] support one of the two electrodes fastened on the outer (movable) section 24, by means of the adjusting screws 20 in the angular position to the other electrode in each instance (in Fig. 2) to the electrode 36, which is fastened at the left end.

ATTACHMENT FOR CLAIM AMENDMENTS

The following is a marked up version of each amended claim in which underlines indicates insertions and brackets indicate deletions.

1. (AMENDED) A CO_2 slab laser having a gas-filled chamber [limited] defined by a tubular housing (10), with at least two electrodes that extend into the tubular housing, said electrodes [overlap] overlapping one another and [form] forming a discharge chamber, and [with] resonator mirrors provided within said housing, characterized in that

[- the] said electrodes are each [held] supported at the opposite ends of [the] said tubular housing,

[- the] said mirrors are [arranged] supported in stationary relationship relative to the electrodes and

[- the] said electrodes[, jointly with the] and mirrors[,] are adjustable relative to one another.

2. (AMENDED) A CO_2 slab laser having a gas-filled chamber [limited] defined by a tubular housing, with at least two electrodes that extend into the tubular housing, said electrodes [overlap] overlapping one another and [form] forming a discharge chamber, and [with] resonator mirrors provided within said housing, characterized in that

[- the] said electrodes are each [held] supported at the opposite ends of [the] said tubular housing,

[- the] said mirrors are designed in one piece with [the] said electrodes and

[- the] said electrodes[, jointly with the] and mirrors[,] are adjustable relative to one another.

3. (Amended) A CO_2 slab laser [according to Claim CO_2 slab laser] having a gas-filled chamber [limited] defined by a tubular housing (10), with at least two electrodes that extend into the tubular housing, said electrodes [overlap] overlapping one another and [form] forming a discharge chamber, and [with] resonator mirrors provided within said housing, characterized in that

[- the] said electrodes each are held at the opposite ends of [the] said tubular housing,

[- the] said mirrors are [arranged] supported in stationary relationship relative to [the] said electrodes and

[- the] said electrodes[, jointly with the] and said mirrors[,] are adjustable relative to one another.

5. (Amended) A CO_2 slab laser according to Claim 3, characterized in that the electrodes are designed in one piece with the end pieces.

9. (Amended) A CO_2 slab laser according to Claim 7, characterized in that the flexible bearing is a bellows.

11. (Amended) A CO_2 slab laser according to Claim 9, characterized in that the adjusting elements contain piezoelectric crystals which are capable of being driven electrically.

09/831698
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[Translation from German]

P.6579 PCT

CO_2 Slab Laser

The invention relates to a CO_2 slab laser according to the generic clause of the main claim.

Slab lasers are disclosed in previous applications of, among others, the holder of this patent (e.g., WO 94/15384). Their geometry is characterized in that between two platelike electrodes, substantially parallel to one another, a narrow discharge chamber is formed for a gas, in particular CO_2, which is excited by a high frequency voltage applied to the electrodes. For obtaining a laser effect, resonator mirrors are arranged on the opposite faces of the narrow discharge chamber formed by the electrodes.

As prior art there may be mentioned an article in a US periodical, N. Iehisa et al., "Performance characteristics of sealed-off CO_2 laser with $La_{1-x}SrxCoO_3$ oxide cathode," Journal of Appl. Phys 59 (1986), pages 317 to 323, in which a streamed gas laser with annular electrodes that [have] no cooling function as well as external mirrors provided outside of Brewster windows has already been described, where in one embodiment a partial reflector also is mounted on the outside on an end piece, so that the mirror, together with the electrodes, can be varied in its relative position.

To be mentioned in addition is US Patent 5,140,606, in which is shown, in a slab waveguide laser, an annular flexible bearing sealing off the laser chamber for adjusting at least one mirror separately from the electrodes.

Additional prior art is disclosed in European patent applications with publication numbers 0,275,023 A1, 0,305,893 B1 and 0,477,864 A1.

Common to all the abovementioned designs is that they have internally-cooled electrodes parallel to one another, which form between their plane surfaces turned toward one another a gas-filled chamber containing a gas to be pumped. Each of these electrodes has to be provided with a complicated fastening in the resonator chamber, especially since thermal deformation results in problems in making adjustment or readjustment, which substantially determines the laser output in an unstable resonator.

At the same time, care must be taken to see that the units to be adjusted are located in a closed chamber, through whose walls is passed as little as possible transmission, since these are very hard to seal off. In particular, seals of flexible materials cause problems, since they "gas out." But even when such seals are avoided, unavoidable sealing gaps result in critical sealing problems.

The object of the invention now is to procure a very small simple laser, wherein as few parts as possible are designed to result in low-cost manufacture. According to the invention, this is accomplished by a CO_2 slab laser having the features of the main claim. The dependent claims present advantageous embodiments of the invention.

This makes it possible to build a very tight metallic housing. A quartz housing has the same tightness advantages, since it can be soldered with metal.

It is particularly advantageous to obtain a gas-filled chamber having complete gas tightness that is limited by movable end pieces, designed as flexible bellows, for tilting about a small angle, and in which the electrodes lying opposite one another are borne by the respective end pieces [and] are arranged lengthwise to the tubular housing. At the same time, alignment of the mirrors, which are arranged on the electrodes or on the end pieces, in any case stationary relative to the electrodes and end pieces, may be effected by adjusting screws mounted on the end pieces outside the gas-filled chamber by way of the existing fixed connection of the electrodes with the end pieces (or by the one-piece design in one of the two elements, end piece or electrode). Leads through the wall of the gas-filled chamber need not be provided.

Adjusting elements, which are formed between two sections of the respective end piece, which due to having at least one groove - more advantageously two grooves arranged staggered, one from the inside and one from the outside - serve to position the sections of the end piece at an angle to one another in such a way that the outer (movable) section to which the respective electrode is fastened is adjustable in its angular position, since the thin wall thickness left between the grooves permits a small angular variation by elastic and/or plastic deformation of the material. The wall acts as a flexible bearing, similar to a bellows or an elastic membrane with small tilting motions of the outer annular surface relative to the inner annular surface.

It is proposed that the movable sections of the end pieces may be connected to one another by spring preloaded tension rods that are in connection with the respective other movable end piece, in order so to exert a constant restoring force on the movable end sections.

The gas-filled chamber is formed by a tubular housing, which assumes a variety of tasks. First of all, it is designed to serve to receive the laser gas mixture, but at the same time also to keep the sections to which the electrodes and hence, also the mirrors, are fastened at a constant distance apart. In addition, it isolates the two electrodes electrically from one another. Therefore, nonconducting materials, which advantageously should have little heat expansion, high gas tightness and high rigidity, are particularly suitable as material for the tubular housing. Quartz glass and aluminum oxide ceramic are proposed.

Shielding for the resultant electrical radiation is provided on the outside of the nonconducting tubular housing. Advantageously, this at the same time serves as inductance for the electrodes. Such shielding may be designed as wire mesh, metal bellows or metal foil. Separate shielding is not necessary in a metal housing, nor when only the surface is metallized. Then, to obtain suitable inductance of the tubular housing, in order to stabilize the discharge excited in the inside under HF conditions, the internal geometry, in particular the volume of the envelope, may be adapted to the inductance.

Since the mirrors of a laser according to the invention have no internal cooling and possess no special possibility of adjustment to the electrode, since mirror and electrode form a unit (either made in one piece or bolted firmly together), the heat that is produced in the mirrors is passed on to the electrode. Now, for these electrodes to have as little

thermal deformation as possible, they are designed with a semicircular cross section and are cooled internally by cooling bores. These cooling bores contain a cooling medium delivered by a cooling medium pump or advantageously a medium or vapor, which by free convection flow and/or by capillary action, as well as by phase transitions on the walls of the hollow chambers or capillaries, carry heat or latent heat away from the inner walls of the cooling bore.

Advantageously, at the end pieces of the tubular housing, outside the gas chamber, there are provided air coolers, to whose cooling ribs run the cooling lines formed by the cooling bores of the electrodes. For the purpose of better heat emission, flow against these cooling ribs may be provided from the outside by blowers. Efforts are made to use natural circulation according to the "heat pipe" principle. Heat pipes are hermetically sealed and evacuated hollow cylinders whose interior may contain any desired medium, e.g., water, which, at a conventional selected negative pressure, boils at low temperatures.

For example, under these negative pressure conditions water takes up only a small part of the free space, the rest being occupied by water vapor. There the water and water vapor serve for transfer of heat from a heated region of the tube to a cooled one (colder region), in other words, absorption or emission of heat by the water takes place not so much on the basis of heat capacity, but predominantly by latent heat in phase transition. Thus, quantities of heat are transported at very small temperature differences. The principle of the heat pipe was discovered back in 1942 and is used mostly in space technology.

According to the invention, in this way bulky cooling systems are avoided and a smaller and simpler laser is made possible, in which (provided with air coolers at both ends) only HF energy need be supplied from a HF line in order to obtain laser light. No additional cooling agent lines or power supplies are necessary.

The ensured gas tightness results in maximum gas service life, since no impurities penetrate from outside. Thus, the availability of the laser is limited over time only by the decomposition of gas, as well as by gas contamination due to the sputter effect in the gas discharge.

Additional features and advantages of the invention follow from the following description of a preferred example of the invention, wherein

Fig. 1 shows the laser according to the invention with cooling means at both ends in a perspective general view;

Fig. 2, the laser according to the invention for external cooling circuit in a partial sectional view, where the two electrodes with cooling medium channels, as well as the structure of the end pieces with flexible bearings, can be seen;

Fig. 3, a flexible bearing end piece in a perspective view;

Fig. 4, the end piece of Fig. 3 in a sectional view;

Fig. 5, the laser structure of Fig. 2 in longitudinal section;

Fig. 6, an exploded view of the laser structure with a shielding netting surrounding

the tubular housing and

Fig. 7, a laser structure with a tubular housing that in its center is provided with a flexible bellows.

The laser according to the invention, which is represented in Fig. 1, consists of a tubular housing 10, about which is stretched a shielding netting 12, in the event that a nonconducting material is used as shielding material. Metallization of the outer surface is alternatively possible. At the two ends are located end pieces 14, through which the electrodes 34, 36 are passed and on which air coolers 16 advantageously are mounted. A HF line, whose connection 18 can be seen in the right-hand side of the figure, is passed through one end piece with its air cooler. The laser light energy will exit through the other end piece with air cooler.

Adjusting screws 20 are provided on each of the end pieces, and under the shielding netting 12 the movable sections of the end pieces are connected together by tension rods 22. The tension rods 22 act upon the end pieces 14 in such a way that they in each instance pull together the movable sections 24, which are separated by grooves 28 from the fixed sections 26. So that the end pieces 24 still have mobility, spring assemblies 30 are provided under nuts 32 on the backs of the sections 24 pointing away from one another.

This makes it possible, by means of the adjusting screws 20, to adjust the end pieces, which as shown in Fig. 2, each bear one of the two electrodes fastened on the outer (movable) section 24, by means of the adjusting screws 20 in the angular position to

the other electrode in each instance (in Fig. 2) to the electrode 36, which is fastened at the left end.

In addition, one of the mirrors, namely the mirror 38, which is fastened to the lower electrode 34 by a bolt, is represented in Fig. 2. It can further be seen that three adjusting screws 20 and three tension rods 22 are proposed in order to obtain optimal adjustability. There the tubular housing 10 is designed cylindrical, while the electrodes 34, 36 in section form a circular segment whose radius is smaller than the inside radius of the tubular housing. The laser gas chamber thus is optimally utilized.

The cooling channels 40 within the electrodes, as well as the semicircular cross section of the electrodes 34, 36, may likewise be seen. The cooling medium bores 40 are connected either to air coolers 16 or to externally connected supplies and returns 42, 44, which lead to conventional external cooling circuits.

So that a crosspiece with a thin wall thickness is obtained, the grooves 28 according to the invention advantageously are supplemented by a groove 48 on the inside, as may be seen in Figs. 3 and 4. The foot 50 of the electrode, enlarged in diameter, is then fitted into a narrow recess 46 on the outer side of the end pieces.

In Fig. 5, as in Fig. 2, the arrangement is again shown in longitudinal section. Here it can be seen that the mirrors 38, fastened on the electrodes in each instance, are opposite one another in the gas chamber. As already described in detail in the aforementioned printed sources of the prior art, HF energy is applied to the electrodes electrically isolated from one another, so that a gas discharge takes place between the

electrodes, while for output the output mirror is designed shorter than the return mirror, so that part of the laser light energy is emitted. There the number of reflections and hence optimal utilization of the reflection is strongly dependent upon the correct adjustment.

This adjustment can be obtained with the adjusting screws 20 by varying the position of the outer sections of the end pieces 24 relative to the inner sections of the end pieces 26. It is alternatively possible to arrange piezoelectric crystals in the adjusting screws, in order to finely adjust the resonator or, if necessary, readjust it in operation. Such piezoelectric crystals may alternatively be provided in the electrodes themselves, in order to counteract the thermal deformation of the electrodes depending on laser light output.

In the right-hand section of the drawing, it can clearly be seen that these are one-piece end pieces. A soldered or welded general structure is preferable, wherein the two sections 24, 26 of the end pieces 14 (as well as the housing surrounding the gas-filled chamber with the sections 26 and the electrodes 34, 36 in each instance with the section 24) are connected together gas-tight. Cementing together or sealing by sealing rings would not provide such good gas tightness.

At the same time, adjustability of the electrodes with the mirrors may alternatively be provided only at the time of assembly, and later be fixed after adjustment by welding, soldering or cementing of the mounting. In this case, it is not necessary to attach the adjusting elements to the laser or to leave them on it.

Lastly, with reversal of the ends on the right and left, an exploded view of the

structure is seen again in Fig. 6, where the beam exit 52, which leaves the laser structure off-center on the end opposite the HF supply 18, can be seen.

Fig. 7 shows the CO_2 slab laser in an additional embodiment, in which the tubular housing 10 is designed in two parts, connected in the center by flexible bellows 54, where the two parts are designed adjustable relative to one another.

CLAIMS

1. CO_2 slab laser having a gas-filled chamber limited by a tubular housing (10), with at least two electrodes that extend into the tubular housing, overlap one another and form a discharge chamber, and with resonator mirrors, characterized in that

- the electrodes are each held at the opposite ends of the tubular housing,
- the mirrors are arranged stationary relative to the electrodes and
- the electrodes, jointly with the mirrors, are adjustable relative to one another.

2. CO_2 slab laser having a gas-filled chamber limited by a tubular housing, with at least two electrodes that extend into the tubular housing, overlap one another and form a discharge chamber, and with resonator mirrors, characterized in that

- the electrodes are each held at the opposite ends of the tubular housing,
- the mirrors are designed in one piece with the electrodes and
- the electrodes, jointly with the mirrors, are adjustable relative to one another.

3. CO_2 slab laser according to Claim CO_2 slab laser having a gas-filled chamber limited by a tubular housing (10), with at least two electrodes that extend into the tubular housing, overlap one another and form a discharge chamber, and with resonator mirrors,

characterized in that

- the electrodes each are held at the opposite ends of the tubular housing,
- the mirrors are arranged stationary relative to the electrodes and
- the electrodes, jointly with the mirrors, are adjustable relative to one another.

4. CO_2 slab laser having a gas-filled chamber limited by a tubular housing, or *[Claim?]* 2, characterized in that the electrodes are held by the end pieces sealing off the tubular housing.

5. CO_2 slab laser according to Claim 3, characterized in that the electrodes are designed in one piece with the end pieces.

6. CO_2 slab laser according to Claim 3 or 4, characterized in that the mirrors are designed in one piece with the end pieces.

7. CO_2 slab laser according to any one of the preceding claims, characterized in that the tubular housing (10) is designed in two parts, where the two parts are designed adjustable relative to one another.

8. CO_2 slab laser according to Claim 3, 4 or 5, characterized in that at least one of the end pieces is attached to the tubular housing (10) by way of a flexible bearing.

9. CO_2 slab laser according to Claim 7, characterized in that the flexible bearing is a bellows.

10. CO_2 slab laser according to any one of the preceding claims, characterized by adjusting elements (20) that are supported on the tubular housing and act on the electrodes.

11. CO_2 slab laser according to Claim 9, characterized in that the adjusting elements contain piezoelectric crystals which are capable of being driven electrically.

12. CO_2 slab laser according to any one of the preceding claims, characterized in that the tubular housing (10) is designed cylindrical and the electrodes in section form a circular segment whose radius is smaller than the inside radius of the tubular housing.

13. CO_2 slab laser according to any one of the preceding claims, characterized in that the electrodes and hence the mirrors are fixed relative to one another after adjustment.

Abstract

CO_2 Slab Laser

CO_2 slab laser having a gas-filled tubular housing, sealed off at both ends by end pieces, which accommodates two overlapping electrodes extending into the tubular housing and mirrors arranged in the region of the electrodes, where each of the two end pieces holds an electrode (34, 36), the mirrors are arranged stationary relative to the electrodes and the electrodes, jointly with the mirrors, are adjustable relative to one another.

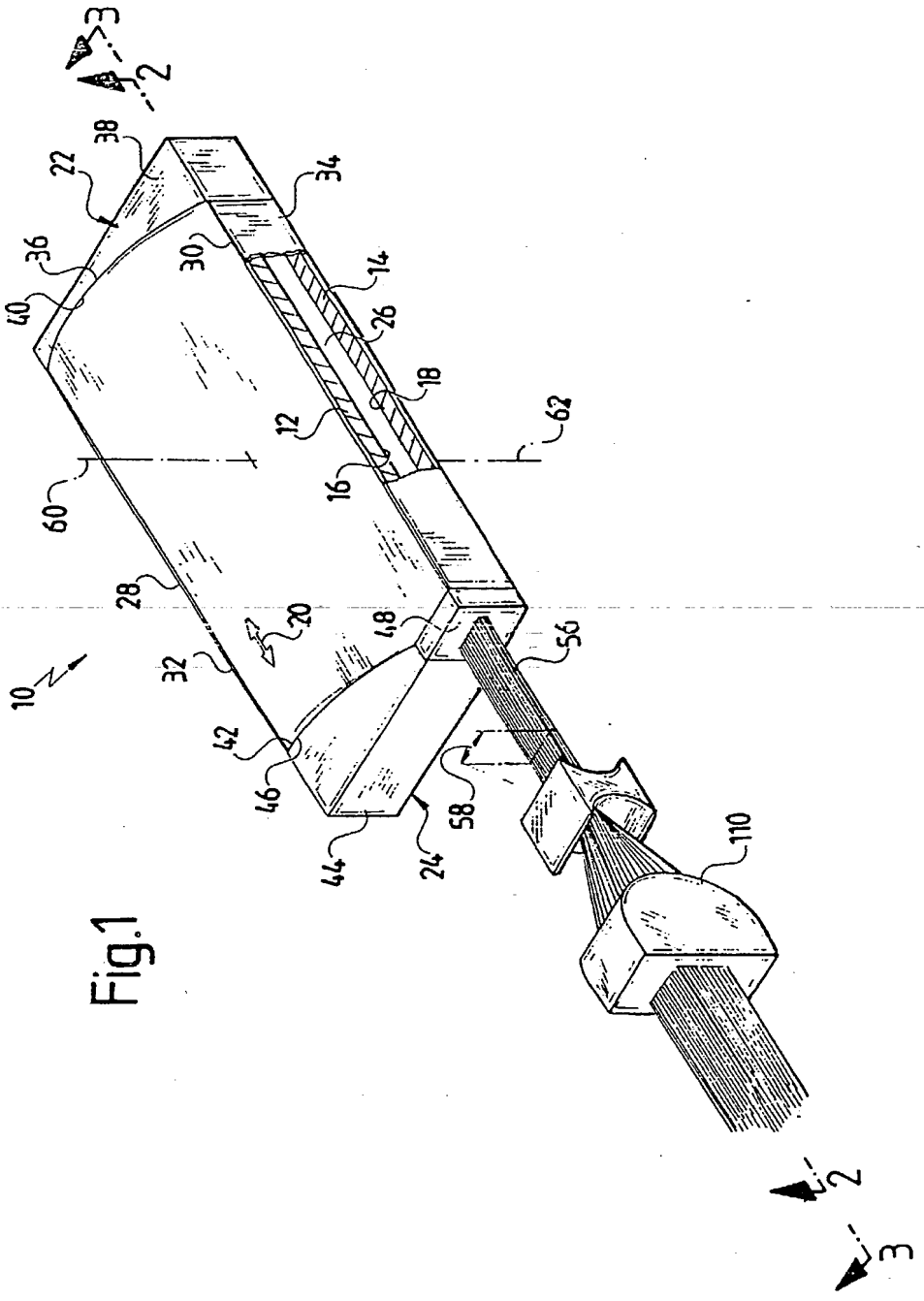


Fig.1

Fig. 2

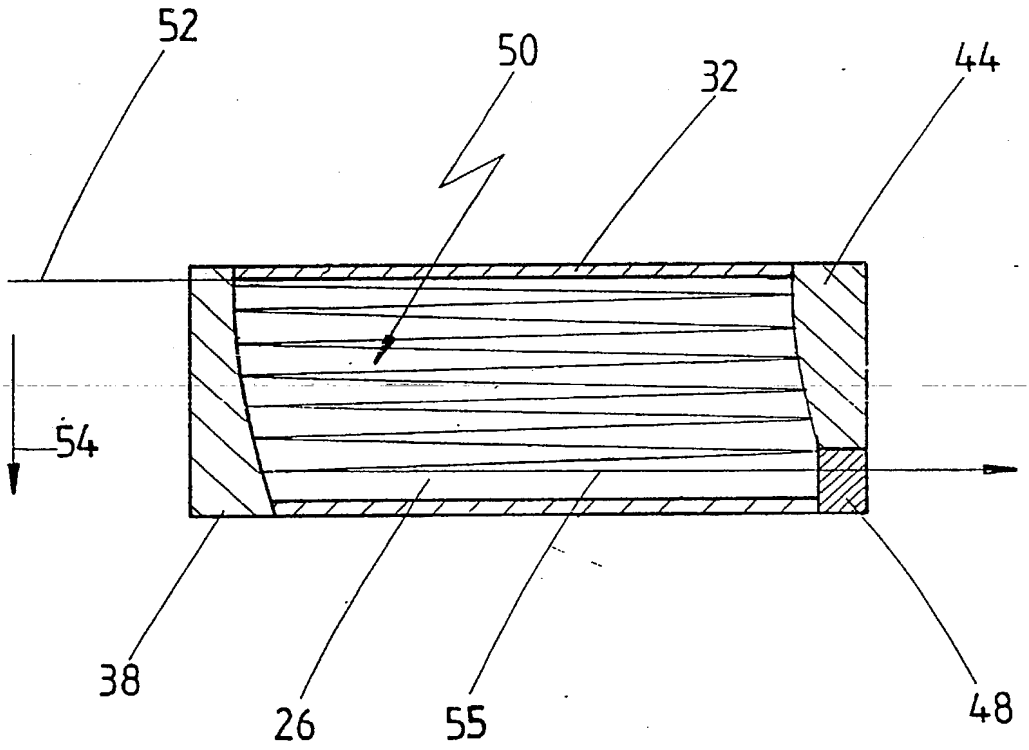


Fig. 3

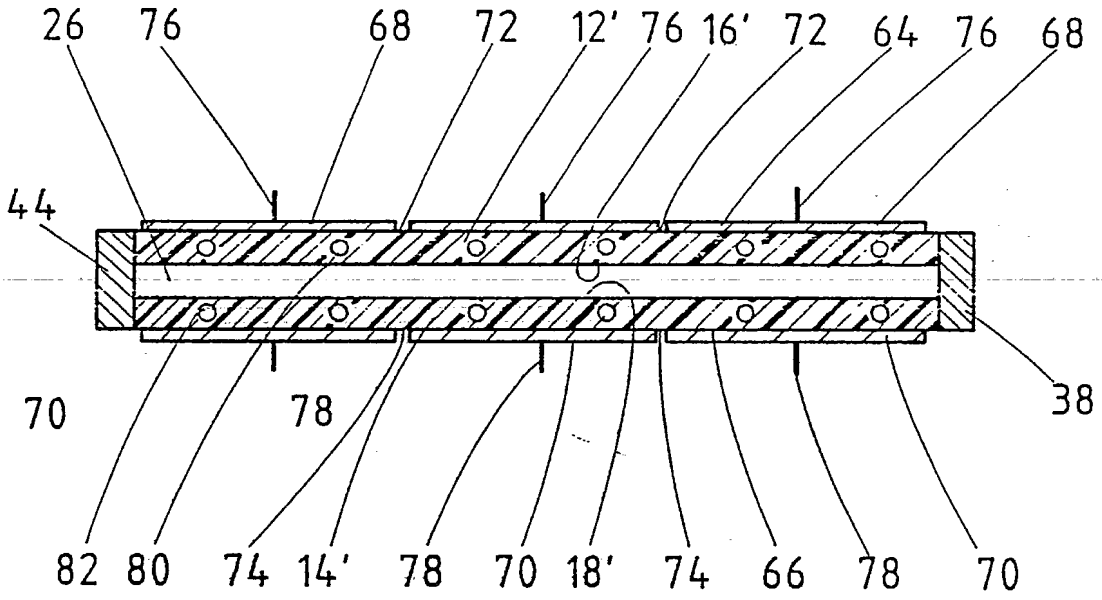


Fig. 4

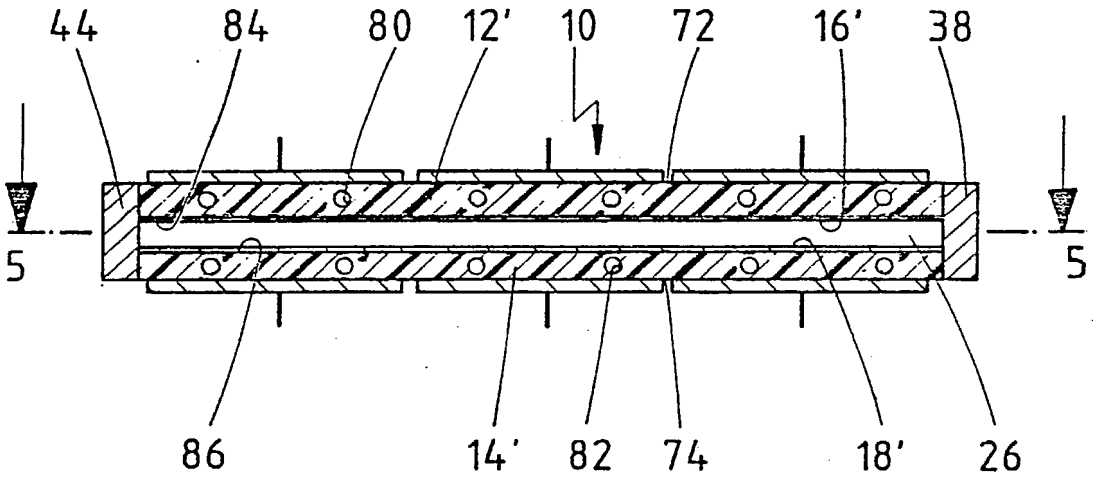


Fig. 5

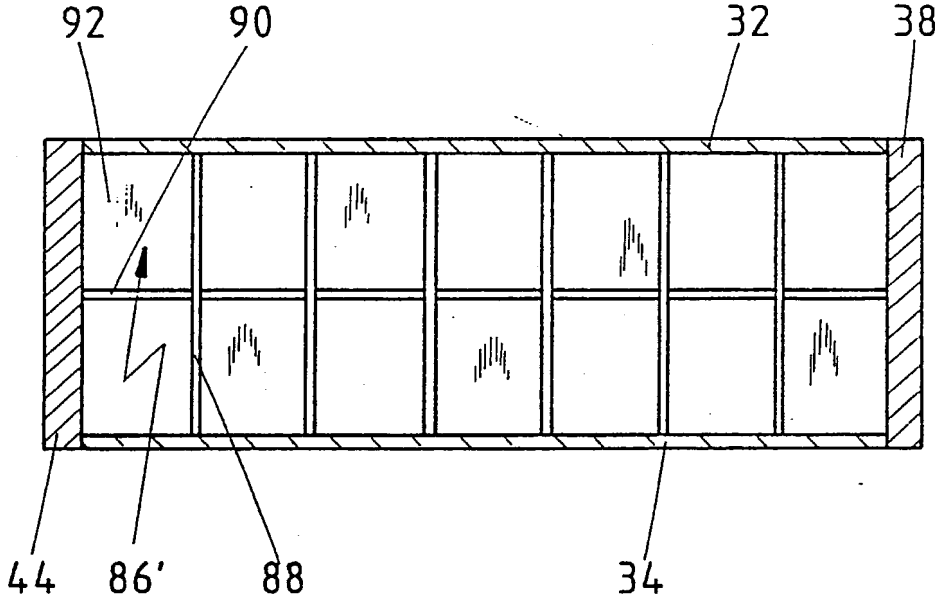


Fig.6

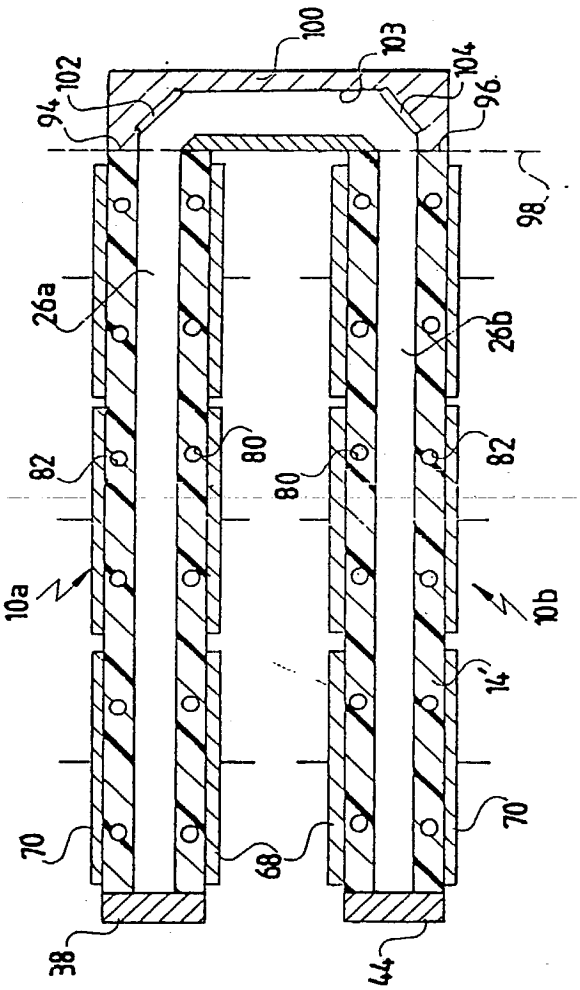
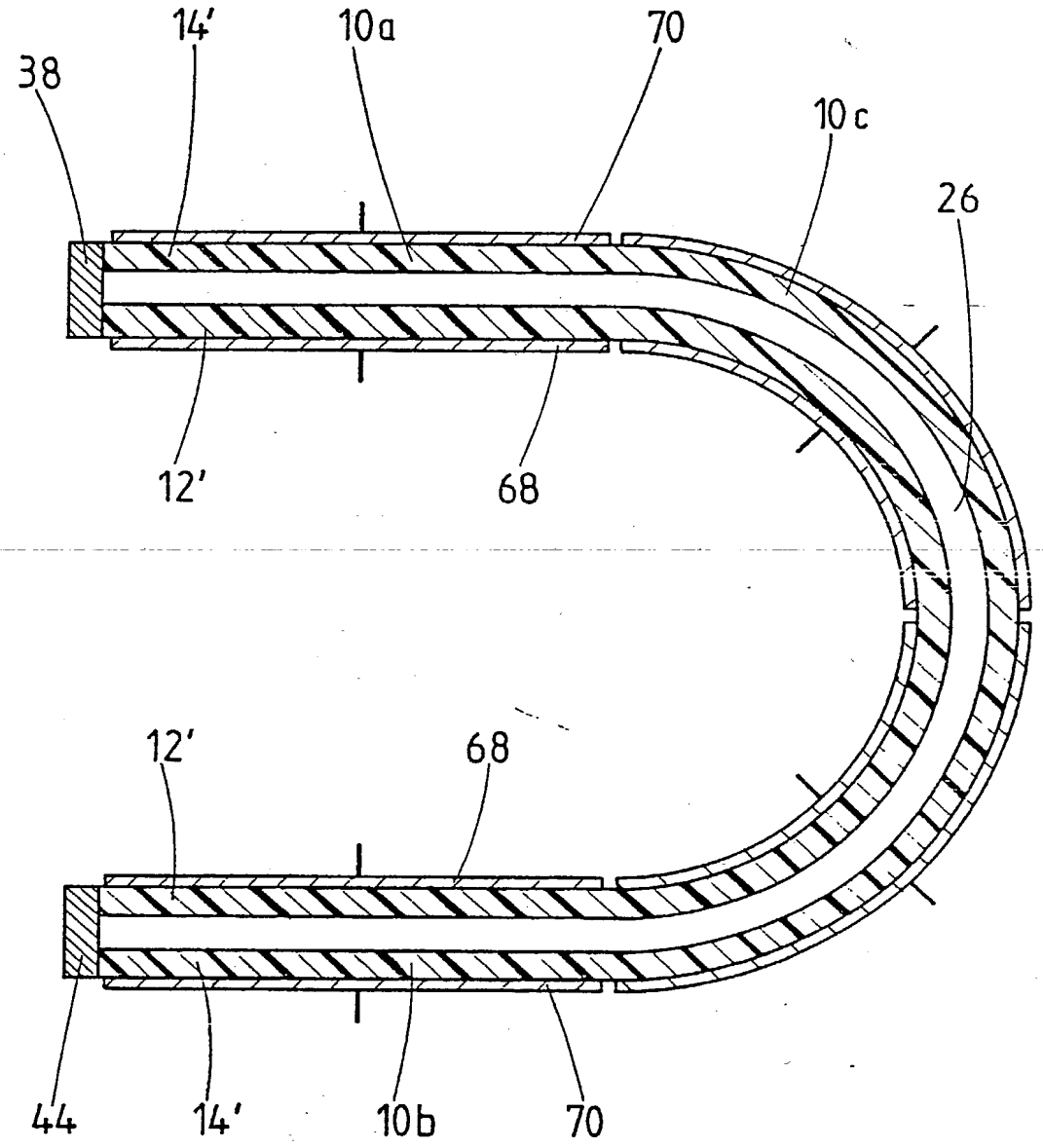


Fig. 7



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HDP/SB/103 based on PTO/SB/103 (8-96)

Declaration and Power of Attorney for Patent Application
Erklärung für Patentanmeldungen mit Vollmacht

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CO_2 Slab Laser

deren Beschreibung hier beigefügt ist, es sei denn (in diesem Falle Zutreffendes bitte ankreuzen), diese Erfindung

☒ wurde angemeldet am May 11, 2001
unter der US-Anmeldenummer oder unter der
Internationalen Anmeldenummer im Rahmen des
Vertrags über die Zusammenarbeit auf dem Gebiet
des Patentwesens (PCT)
09/831,698 und am
May 11, 2001 via Preliminary Amendment
filed with application abgeändert (falls
zutreffend).

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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

CO_2 Slab Laser

the specification of which is attached heretounless the following box is checked:

☒ was filed on May 11, 2001
as United States Application Number or PCT
International Application Number
09/831,698 and was amended on
May 11, 2001 via Preliminary Amendment filed with application (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

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Prior Foreign Applications
(Frühere ausländische Anmeldungen)

		Priority Not Claimed Priorität nicht beanspruct
198 52 284.3 (Number) (Nummer)	Germany (Country) (Land)	13 November 1998 (Day/Month/Year Filed) (Tag/Monat/Jahr der Anmeldung) ☐
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_____ (Application No.) (Aktenzeichen)	(Filing Date) (Anmeldetag)

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PCT/DE99/03570 (Application No.) (Aktenzeichen)	November 9, 1999 (Filing Date) (Anmeldetag)	Published (Status) (patented, pending, abandoned) (Status) (patentiert, schwebend, aufgegeben)
_____ (Application No.) (Aktenzeichen)	(Filing Date) (Anmeldetag)	(Status) (patented, pending, abandoned) (Status) (patentiert, schwebend, aufgegeben)

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Unterschrift des Erfinders Datum 13.6.01	Inventor's signature Date 13.6.01
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Unterschrift des zweiten Erfinder Datum	Second Inventor's signature Date
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